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Simulations of nuclear cluster formation

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Abstract. Preliminary results are presented about a fully self-consistent N-body simulation of a sample of four massive globular clusters in close interaction within the central region of a galaxy. The N-body representation (with $N = 1.5 \times 10^6$ particles in total) of both the clusters and the galaxy allows to include in a natural and self-consistent way dynamical friction and tidal interactions. The results confirm the decay and merging of globulars as a viable scenario for the formation/accretion of compact nuclear clusters. Specifically: i) the frictional orbital decay is ~ 2 times faster than that predicted by the generalized Chandrasekhar formula; ii) the progenitor clusters merge in less than 20 galactic core-crossing time (t_b); iii) the NC configuration keeps a quasi-stable state at least within $\sim 70 t_b$.

Key words. Stellar Dynamics – Methods: numerical – Galaxies: kinematics and dynamics – Galaxies: star clusters

1. Introduction

We present the preliminary results of a fully self-consistent N-body simulation concerning the close interaction of a sample of four massive globular clusters (GCs) in the central region of a galaxy. Both the clusters and the galaxy are represented by mutually interacting particles, thus including in a natural and self-consistent way dynamical friction and tidal interactions. This study represents a substantial improvement in the analysis of the frictional decaying and merging of GCs in galactic nuclear regions, a scenario first tackled by semi-analitical approaches (Tremaine et al. 1975; Capuzzo-Dolcetta 1993) and then pursued by N-body experiments (Oh & Lin 2000; Capuzzo-Dolcetta & Miocchi 2008a). Clarifying the role of the above-mentioned dynamical effects is important also to understand the formation and origin of Nuclear Clusters (NCs) (e.g. Oh & Lin 2000; Bekki et al. 2004).

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2. Methods and results

Each GC is represented by 256,000 particles initially distributed according to a King profile whose structural parameters are taken from the set of the most compact clusters simulated in Capuzzo-Dolcetta & Miocchi (2008a). The GCs are initially located at rest within the galactic core (see Fig. 1). The galaxy is represented by a spherical and isotropic Plummer phase-space distribution sampled with 512,000 particles. The N-body simulation is performed with our own parallel tree-code using individual and variable time-steps (Miocchi & Capuzzo-Dolcetta 2002).

The simulation results can be re-scaled with any given set of galactic structural parameters. One possible choice for these parameters is the following: core radius $r_b = 200$ pc; core-

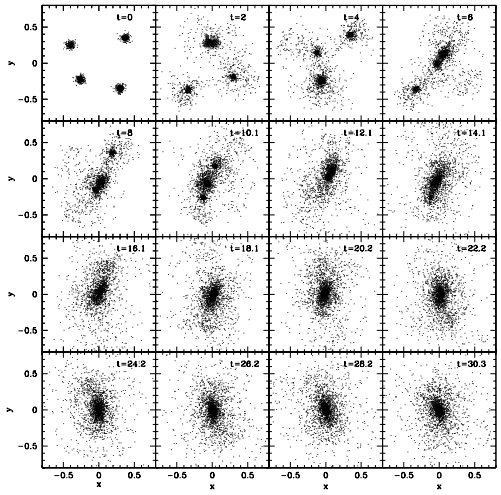

Fig. 1. Time sequence of the merging event of the 4 GCs. Time and lengths are in unit of t_b and r_b.

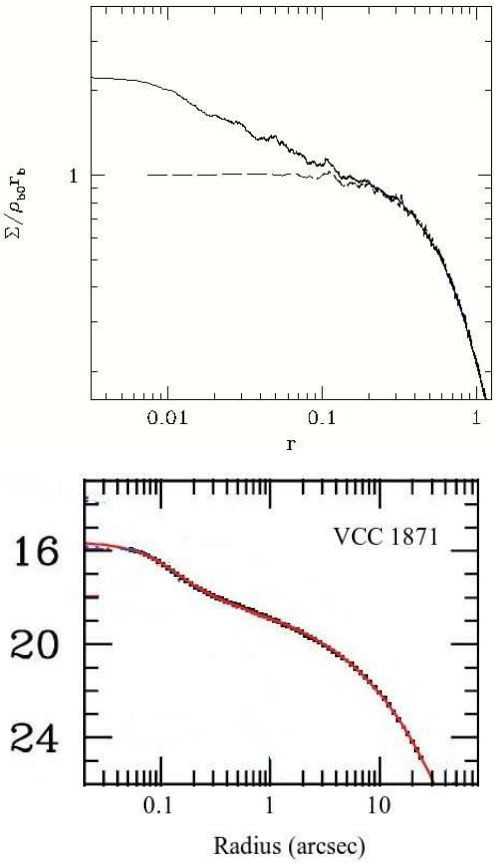

Fig. 2. Top: total projected surface density profile (solid line) of the last configuration of our NC simulation (the dashed line is the galactic profile only). r is in unit of r_b. Bottom: the observed profile for the nucleated galaxy VCC 1871 (Côté et al. 2006).

crossing time $t_b = 0.54$ Myr; central density $\rho_{b0} = 370\ \mathrm{M}_\odot\ \mathrm{pc}^{-3}$.

The main results can be summarized as follows: i) the frictional orbital decay is $\sim$ 2 times faster than that given by the use of the generalized Chandrasekhar formula (Pesce et al. 1992); ii) the progenitor clusters (initially located within the galactic core) merge in less than 20 galactic core-crossing time ($\sim$ 11 Myr), see Fig. 1 and Capuzzo-Dolcetta & Miocchi (2008b); iii) the NC configuration is quasi-stable at least within the simulated time ($\sim 70 t_b \sim$ 40 Myr); iv) the total surface density profile has the typical appearance of a nucleated galaxy central profile (Fig. 2); v) the global velocity dispersion profile *decreases* towards the centre as found in the Geha et al. (2002) observations. These results are described in more detail in Capuzzo-Dolcetta & Miocchi (2008b).

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